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Control of Cotton Wilt and "Rust," or Potash Hunger, by the Use of Potash-Containing Fertilizers

V. H. YOUNG

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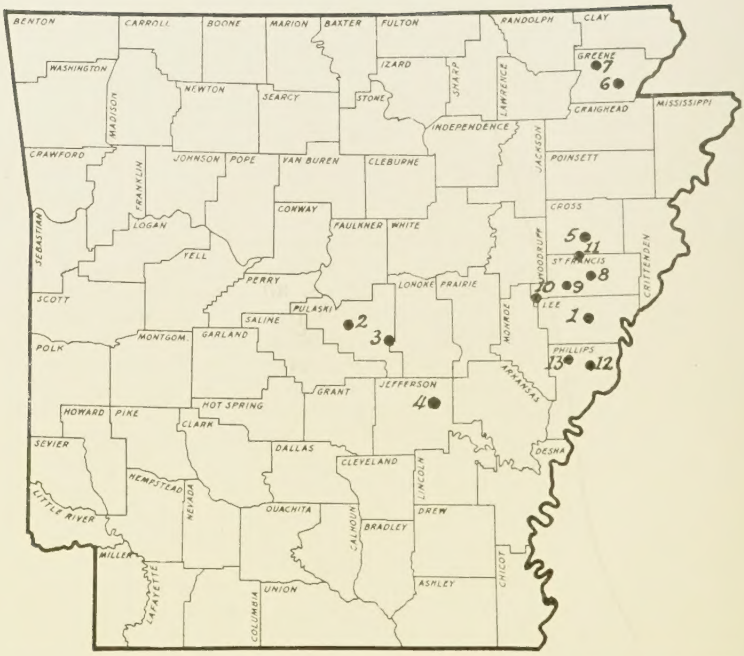

Figure 1. Map of Arkansas showing location of the 9-year study near Cotton Branch Experiment Station in Lee County 1929-1937, and of the fertilizer tests in various counties studied in 1930 and 1931. (1) Cotton Branch Experiment Station near Marianna, (2) North Little Rock, (3) Scott, (4) Altheimer, (5) Wynne, (6) Paragould, (7) Beech Grove, (8) Forrest City, (9) Palestine, (10) Wheatley, (11) Colt, (12) Barton, (13) Marvell.

CONTROL OF COTTON WILT AND "RUST," OR POTASH HUNGER, BY THE USE OF POTASH-CONTAINING FERTILIZERS

V. H. YOUNG
Department of Plant Pathology

CONTENTS

The work reported in this bulletin is concerned primarily with the control of cotton wilt and "rust," or potash hunger, in the alluvial soils of eastern Arkansas, although a few isolated experiments conducted in the central part of the state are reported. Part of the data has been published previously,[1] but is included here in a greatly condensed form, in order to present as complete a picture as possible of this phase of the work. The period covered by these studies extends from 1929 to 1937, and the work is concerned primarily with establishing the basic facts concerning the relation of fertilizers to the control of cotton wilt and "rust." The data apply only to the wilt of ordinary upland cotton (*Gossypium hirsutum* L.) caused by *Fusarium vasinfectum* Atk.

Atkinson (*1*), in his pioneer studies of the cotton wilt disease, noted that it was confined to certain soil types, and since that time it has been noted repeatedly that the clayey soils of the Piedmont section of the eastern cotton states and similar Upland soils in other parts of the Cotton Belt are comparatively free of the disease, whereas the coastal plains area and the sandy alluvial soils of the larger river valleys are extremely favorable to the disease. Seasonal variations in the incidence of cotton wilt are likewise very great. Furthermore, root injury caused by the root-knot nematode, *Heterodera marioni* (Cornu) Goodey, has been recognized for many years as an important factor contributing to the susceptibility of the cotton plant to attacks of the cotton-wilt disease.

It was this marked effect of environment, particularly with respect to the soil, on the incidence of the disease that may have caused early workers to look to the use of fertilizers as a possible method of controlling cotton wilt. Atkinson called attention to

[1] Ark. Agr. Expt. Sta. Bulletins 234, 272, and 308, and Annual Reports covering the period July 1, 1928, to June 30, 1937. J. O. Ware and Geo. Janssen were junior authors of Bulletins 234 and 272, and J. O. Ware was senior author of Bulletin 308.

the relation of potash fertilizers to "rust" of cotton, and it was recognized at an early date that "rust," the term commonly used, was in reality "potash hunger." Since cotton wilt and "rust" are often confused in the popular mind, it seems probable that earlier attempts by farmers to control cotton wilt by use of various fertilizer combinations containing potash may have arisen from this confusion. Nevertheless, there had developed in Arkansas at least a belief among many farmers that potash fertilizers were effective for the control of cotton wilt.

The first attempts to control cotton wilt through the use of fertilizers by Orton (*10, 11*) and Lewis (*3*) in the eastern cotton states gave negative results which were later confirmed in Florida by Walker (*13*). Fulton (*2*) in Louisiana also secured negative results from the use of potash fertilizers, although he reported favorable results from the use of various organic manurials. These negative results, unfortunately, tended to discourage further work along this line. Rast in 1920 in Arkansas (*12*) was the first to report positively the reduction in the incidence of cotton wilt through the use of potash-containing fertilizers. Further work by the writer and his associates in Arkansas (*14, 15, 16*), and by Neal (*7, 8, 9*) and Miles (*4, 5, 6*) in Mississippi has confirmed the work of Rast, so far as the states of Arkansas and Mississippi are concerned. Sherbakoff, in an oral report,[2] stated in 1936 that results obtained with potash fertilizers in Tennessee confirm those published by workers at the Arkansas and Mississippi stations.

EXPERIMENTAL METHODS AND RESULTS

As has been previously stated, the basis for starting work on the relation of fertilizers to the cotton-wilt disease was the constantly repeated opinion of a few progressive farmers in the state that potash fertilizers controlled the disease, plus the extremely promising results of Rast. For this reason comparatively simple fertilizer studies were indicated as the first point of attack.

For convenience a site near the Cotton Branch Experiment Station in Lee County was selected where cotton was known to have been severely affected with cotton wilt for several years previously. The soil was clearly of the alluvial type characteristic of the river valleys of eastern Arkansas, and, according to soil maps, apparently should be classified as a Lintonia silt loam. This site, known throughout this bulletin as the Govan Place, was first utilized in 1929 and work continued there through the sea-

[2] Presented by Dr. C. D. Sherbakoff at the meeting of the Southern Section, American Phytopathological Society, February, 1936, Jackson, Miss.

son of 1935, a period of 7 years. Other work on the Brittain Place, also near the Cotton Branch Experiment Station, was initiated in 1933 and results for 5 years are now available from this work. In 1930 and 1931 data bearing on the effect of fertilizers on the cotton-wilt disease were secured from 13 fertilizer demonstrations in central and eastern Arkansas.

For the sake of clearness, the work on the Govan Place from 1929 to 1932 is designated as Experiment I, the work on the Govan Place from 1933 to 1935, which was moved to immediately adjacent land on the same farm and modified somewhat, is designated as Experiment II, the work on the Brittain Place is designated as Experiment III, and the scattered data secured from the fertilizer demonstrations comprise Experiment IV. In Experiments I to III care was taken to select land where root knot or nematode disease was not a factor, and in only one of the several experimental fields studied in Experiment IV was root knot present. Special attention will be called to this fact when the data for that field are presented.

Experiment I

As was previously noted, this work extended over a period of 3 years, from 1929 to 1931. The plot of land on the Govan Place consisted of fairly uniform Lintonia silt loam soil, and was approximately 1 1/3 acres in area. Observations made in 1927 and 1928 indicated that both "rust," or potash hunger, and cotton wilt were of considerable importance. No evidence of root knot or nematode disease could be found.

Fertilization was based on 500 pounds per acre of a 4-10-4 fertilizer which, according to the analysis of the materials used, was equivalent to 133 pounds of nitrate of soda, 312 pounds of superphosphate, and 40 pounds of muriate of potash. There were also used plots fertilized only with nitrate of soda, and plots fertilized only with high amounts of muriate of potash and kainite, which contained equivalent amounts of potassium. In order to study the effects of various combinations, commercial-mixed fertilizers were not used but the commercial salts were employed singly and in combinations. Cottonseed meal at the rate of 600 pounds per acre was also used. Fertilizer was applied under the bed, generally about 10 days or 2 weeks prior to planting, although in 1929 the application was made just before planting. Thinning, cultivation, and other cultural procedures were not varied from the standard practice in that part of the state. Plots were one-thirtieth of an acre in size and there were four replications for each treatment. Permanent markers were employed to make certain that each plot was located in exactly the same place

each year of the experiment. Each plot was separated by a non-fertilized buffer row. Trice 304, a moderately wilt-susceptible variety, was used.

Stand counts were made as soon after the final thinning as possible, and the incidence of the cotton wilt disease was recorded at definite intervals throughout the season. Plants which were so nearly dead that it seemed probable that they might disappear before the next wilt count was made, were removed from the row and so recorded. Whenever any doubt regarding the presence of wilt existed, a leaf was removed in order to see whether vascular discoloration was present, or a branch was cut into for the same purpose. Notes were taken on the effects of the fertilizer treatments on the vegetative condition of the crop, especially with respect to the presence or absence of "rust," or potash hunger, and the earliness or lateness of the crop.

The weight of seed cotton for each row at each picking was recorded and this information not only gave evidence of the effect of the various treatments on yields of seed cotton but also gave some evidence of the effect of the treatments on the length of the bearing season.

As noted, wilt counts were taken at intervals throughout the season to make certain that no diseased plants had died and disappeared. It was also desired to secure evidence regarding the effect of the various treatments on the seasonal incidence of the cotton wilt disease. Since no particularly significant seasonal differences from plot to plot were to be noted, these data are not presented for each year. However, the results for the first year's work are presented in detail in order to give a more complete picture of the methods employed. Table 1 gives the various treatments used, the incidence of cotton wilt on July 9, August 14, and September 1, 1929, the final yield of seed cotton, the "percentage of earliness," and the proportion of the total yield of seed cotton secured at the first picking.

It will be seen from Table 1 that differences in the incidence of cotton wilt appear as early as the first wilt count on July 9, but that, by the middle of August, differences are much more clearly indicated, and that these differences persist to the end of the growing season. The figure for so-called "percentage of earliness" seems to indicate that the high-potash applications have decidedly delayed maturity. This impression was also given by a casual examination of the plots, since the high-potash plots remained alive with green foliage and many immature bolls up to frost, whereas the check and no-potash plots matured early and the plants were defoliated and dead several weeks before frost. However, when one examines the yield data, it becomes apparent that the high-potash plots gave as much or more seed cotton at the first picking than the no-potash plots, and that

TABLE 1. EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON THE INCIDENCE OF COTTON WILT, YIELD OF COTTON, AND PERCENTAGE OF EARLINESS (VARIETY, TRICE 304), GOVAN PLACE NEAR COTTON BRANCH EXPERIMENT STATION, LEE COUNTY, ARKANSAS, 1929[1]

Plot treatment and rate per acre	Cotton wilt, July 9	Cotton wilt, Aug. 14	Cotton wilt, Sept. 1 (final)	Yield seed cotton per acre	Earliness
	Per cent	*Per cent*	*Per cent*	*Pounds*	*Per cent*
Nitrate of soda, 300 pounds	2.76	19.4	30.4	340	52.3
Nitrate of soda, 150 pounds	3.60	27.9	40.9	317	43.8
Check, no treatment	1.76	18.2	30.3	237	49.7
Kainite 14 per cent, 1,080 pounds	.87	2.8	6.0	701	17.9
Muriate of potash, 300 pounds	2.71	7.4	13.9	580	22.6
Nitrate of soda, 133 pounds Superphosphate, 312 pounds Muriate of potash, 40 pounds	1.5	14.2	24.9	517	46.2
Superphosphate, 312 pounds Muriate of potash, 40 pounds	2.3	16.2	26.9	446	39.5
Nitrate of soda, 133 pounds Muriate of potash, 40 pounds	1.7	13.3	28.9	482	41.7
Nitrate of soda, 133 pounds Superphosphate, 312 pounds	3.5	28.1	43.8	344	54.6
Cottonseed meal, 600 pounds	3.3	31.4	40.6	332	50.3
Buffer rows, no treatment	3.3	22.6	36.0	298	39.7

[1] Total plant count, 11,446.

the additional cotton picked at the second picking represents increase in yield over that of the no-potash plots, produced after the no-potash plants had matured and died. It should be further noted that the much higher incidence of cotton wilt in the checks and no-potash plots would tend to affect the "percentage of earliness" figure materially, since the diseased plants which produced cotton at all tended to produce it early in the season. "Percentage of earliness," therefore, appears to be a deceptive figure if it is interpreted solely as an indication of the effect of treatments on the earliness of cotton.

The field methods described were carried out through the 3-year period of the experiment and it seems unnecessary, therefore, to present more than the final results, Table 2.

In an experiment of this sort, the data of which are not subjected to statistical analysis, consistency of results over a period of years is perhaps the greatest indication of significance. It must be recognized, however, that the incidence of the cotton-wilt disease is markedly affected by environment, particularly

TABLE 2. SUMMARY OF RESULTS, EXPERIMENT I; EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON INCIDENCE OF COTTON WILT, YIELD OF SEED COTTON, AND PERCENTAGE OF EARLINESS (VARIETY, TRICE 304), GOVAN PLACE NEAR COTTON BRANCH EXPERIMENT STATION, LEE COUNTY, ARKANSAS, 1929-1931[1]

Plot treatment and rate per acre	Cotton wilt (final)				Yield seed cotton per acre				Earliness			
	1929	1930	1931	Average	1929	1930	1931	Average	1929	1930	1931	Average
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Nitrate of soda, 300 pounds	30.4	15.5	21.3	22.4	340	401	1,196	646	52.3	53.5	35.7	47.2
Nitrate of soda, 150 pounds	40.9	23.9	21.1	28.6	316	347	1,153	605	43.8	89.0	33.8	55.5
Check, no treatment	30.3	22.3	18.7	23.7	237	282	769	429	49.7	90.4	52.0	64.0
Kainite, 14 per cent, 1,080 pounds	6.0	2.9	5.2	4.7	700	673	1,631	1,001	17.9	83.1	23.7	41.6
Muriate of potash, 300 pounds	13.9	4.9	4.9	7.9	580	616	1,383	860	22.6	85.9	24.1	44.2
Nitrate of soda, 133 pounds Superphosphate, 312 pounds Muriate of potash, 40 pounds	24.9	9.6	12.8	15.7	517	613	1,700	943	46.2	89.6	37.0	57.6
Superphosphate, 312 pounds Muriate of potash, 40 pounds	26.9	10.1	12.0	16.3	446	456	1,269	724	39.5	91.4	49.3	60.1
Nitrate of soda, 133 pounds Muriate of potash, 40 pounds	28.9	10.5	11.6	17.0	482	415	1,432	776	41.7	88.8	33.7	54.7
Nitrate of soda, 133 pounds Superphosphate, 312 pounds	43.8	20.2	23.5	29.1	343	330	1,032	568	54.6	91.8	51.9	66.1
Cottonseed meal, 600 pounds	40.6	21.9	26.2	29.5	332	392	1,260	661	50.3	88.0	30.4	56.2
Buffer rows, no treatment	36.0	17.7	18.6	24.1	298	356	622	425	39.7	88.9	40.4	56.3

[1] Total plant count for the period, 83,179.

soil and air temperature and soil moisture; and, should it be found that the presence or absence of potash or any other element or combination of elements in the soil affects the incidence of the disease, it need not be supposed that the interaction between temperature and moisture factors and soil nutrients will be such as to give completely consistent data at all times.

Examining the data in Table 2, it is seen that the non-fertilized checks show the most cotton wilt in 1929, decidedly less in 1930, and slightly less in 1931 than in 1930. Likewise, the incidence of wilt in all the treated plots was decidedly higher in 1929 than in the next 2 years. The year, 1929, was evidently very much more favorable from a climatic point of view for the cotton wilt disease than either of the other years. Throughout the 3-year period the incidence of wilt in the kainite plots was consistently low, the maximum amount of wilt (6 per cent) occurring in 1929 and the average for the 3 years amounting to 4.7 per cent. Although the variation in the 3-year period was greater for the muriate of potash plots, the incidence was decidedly lower than for any other treatment except kainite. High applications of potash alone, either as kainite or muriate, have in all of the 3 years brought about such a decided reduction in the incidence of cotton wilt that no reasonable doubt can be held regarding the significance of the results.

All fertilizer combinations based on 500 pounds of a 4-10-4 fertilizer which included only 40 pounds of muriate of potash per acre (treatments 6, 7, and 8 of Table 1) seem to fall in rather consistent groups so far as the incidence of cotton wilt is concerned, the variations being very slight in any particular year and the average results within the group being very close. Since the incidence of cotton wilt for all of these three treatments was each year well below the incidence of the checks, it may be concluded that the application of fertilizer containing as little as 40 pounds of muriate of potash per acre had a significant effect in reducing the incidence of cotton wilt.

The application of relatively high amounts of nitrate of soda alone apparently had little effect on the incidence of cotton wilt, with the exception of the 1929 plots fertilized with 150 pounds of nitrate of soda, which gave a high incidence of wilt seemingly not in agreement with other results. The results for this particular treatment suggest the presence of some unrecognized error.

Cottonseed meal gave inconsistent results, seeming, in 1929 and 1931, to actually favor the development of cotton wilt. Perhaps one of the most striking results was the effect of applications of nitrogen and phosphorus without potassium, which in 1929 actually resulted in practically a 44 per cent increase in the number of wilted plants. It thus appears that in this experiment

high applications of potash have in some way reduced greatly the incidence of cotton wilt, and that low applications of potash in mixed fertilizers rather consistently have given some reductions in the incidence of wilt. Other treatments seemingly have not affected the incidence of cotton wilt, and, in some cases, have actually resulted in increased amounts of the disease.

As was previously mentioned, notes were taken on the growth of the plants and on the amount of "rust," or potash hunger. No satisfactory method was found for expressing this information numerically, but it was nevertheless highly significant. In each of the 3 years, the check plants remained decidedly smaller, matured early, produced few top bolls, and lost their leaves long before frost. The leaf symptoms indicating "rust," or potash hunger, were present in these plots each year. Likewise, the plots fertilized with a nitrate-phosphate mixture showed especially severe symptoms of potash hunger, in spite of the fact that the plants made a greater initial growth. These plants after mid-season had all the appearance of being decidedly out of physiological balance. During the extreme drought of 1930, there was clear-cut evidence that potash-fertilized plants stood the dry weather much better, a fact noted many years before by Atkinson (*1*).

Yields of seed cotton are affected by so many environmental factors that, without carefully analyzed statistical data, it would be unsafe to state what portion of the yield increases was correlated with the control of cotton wilt. Nevertheless, there can be no doubt that heavy increases in yield were in every year associated with some of the fertilizer treatments, and that the three treatments which resulted in the greatest yield increases are also the three which resulted in the lowest incidence of cotton wilt. Inspection of the data suggests, however, that the relationship is much more than an increase in yield due to lowered disease incidence. Rather, one is inclined to believe that, to a considerable extent at least, the increased growth response due to the control of potash hunger, or "rust," has not only rendered the plants more resistant to the attacks of the wilt organism, thus increasing yields, but has also resulted in higher yields of seed cotton because of the lengthened fruiting season.

Experiment II

This experiment was located on plots immediately adjacent to those of the first experiment, a part of the same cotton field. The soil, so far as could be seen, was similar to that used for Experiment I and the incidence and severity of wilt and potash hunger in the 3 previous years were of a similar order.

Results from Experiment I seem to indicate that the quantity of the basic formula employed (500 pounds of a 4-10-4 fertilizer) does not provide enough potash for the most efficient control of the cotton wilt disease. For this reason, a series of applications based on 600 pounds of a 6-8-6 fertilizer was used. This called for 240 pounds of nitrate of soda, 300 pounds of acid phosphate, and 72 pounds of muriate of potash. Plots using twice as much potash (6-8-12), and various other combinations including potash alone in the form of muriate and kainite, both equivalent to the formula 0-0-12, and stable manure at the rate of 10 tons per acre, were also used. For the sake of comparison, one series of plots using 500 pounds of the 4-10-4 formula previously employed was also included. Because cottonseed meal as an organic fertilizer seemed inefficient in the previous experiment, it was omitted. Each treatment consisted of one-fourth of an acre and

TABLE 3. EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON THE INCIDENCE OF COTTON WILT AND YIELD OF SEED COTTON (VARIETY, TRICE 304), GOVAN PLACE NEAR COTTON BRANCH EXPERIMENT STATION, LEE COUNTY, ARKANSAS, 1933[1]

Plot treatment		Wilted plants					Acre yield of seed cotton
Formula	Amount applied per acre	July 5	July 20	Aug. 5	Aug. 20	Sept. 5	
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Check	No treatment	4.0	10.5	13.3	20.6	37.2	644
6-0-0	Nitrate of soda, 240 pounds	2.1	7.0	9.7	17.9	31.8	1123
6-8-0	Nitrate of soda, 240 pounds Superphosphate, 300 pounds	2.8	5.2	12.4	22.2	37.2	994
6-8-6	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 72 pounds	.8	2.8	4.5	8.2	13.3	1665
6-8-12	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 144 pounds	.9	4.1	5.3	7.0	8.1	1813
Check	No treatment	4.4	7.4	10.5	16.3	28.2	692
4-10-4	Nitrate of soda, 133 pounds Superphosphate, 313 pounds Muriate of potash, 40 pounds	1.5	4.2	6.7	10.2	20.1	1311
0-0-12	Kainite, 15 per cent, 480 pounds	.8	3.1	5.6	6.5	8.5	1075
0-0-12	Muriate of potash, 144 pounds	1.1	3.9	5.1	6.0	6.9	1138
0-8-0	Superphosphate, 300 pounds	5.9	12.7	16.5	23.9	40.1	672
Check	No treatment	6.1	14.0	16.8	23.2	37.6	643
	Manure, 10 tons	3.2	10.4	11.2	15.0	18.9	1624

[1] Total plant count, 10,628.

TABLE 4. EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON THE INCIDENCE OF COTTON WILT AND YIELD OF SEED COTTON (VARIETY, TRICE 304), GOVAN PLACE NEAR COTTON BRANCH EXPERIMENT STATION, LEE COUNTY, ARKANSAS, 1932-1935, INCLUSIVE[1]

Plot Treatment		Wilted plants				Yield seed cotton per acre			
Formula	Amount applied per acre	1932	1933	1934	1935	1932	1933	1934	1935
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
6-0-0	Nitrate of soda, 240 pounds	8.9	31.8	24.4	11.96	686	1123	641	428
6-8-0	Nitrate of soda, 240 pounds Superphosphate, 300 pounds	10.0	37.2	36.1	28.06	638	994	593	356
6-8-6	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 72 pounds	7.1	13.3	11.5	4.89	857	1665	875	586
6-8-12	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 144 pounds	5.5	8.1	9.6	4.10	785	1813	849	561
4-10-4	Nitrate of soda, 133 pounds Superphosphate, 313 pounds Muriate of potash, 40 pounds	7.2	20.1	17.7	4.80	768	1344	779	439
0-0-12	Kainite, 15 per cent, 480 pounds	4.6	8.5	6.4	1.64	679	1075	692	445
0-0-12	Muriate of potash, 144 pounds	5.5	6.9	8.8	2.13	685	1138	740	471
0-8-0	Superphosphate, 300 pounds	12.3	40.1	40.8	36.07	452	672	490	188
Check	No treatment	11.5	34.3	30.2	16.50	433	659	438	233
	Manure, 10 tons	.....	18.9	17.5	8.67	.....	1624	844	605

[1] Total plant count for the period, 65,806.

there were four series of plots. Fertilizer was applied about 10 days to 2 weeks prior to planting in the same manner as in Experiment I, except that on the plots where stable manure was used, it was spread evenly on the surface of the whole plot prior to plowing and was then turned under. The Trice 304 variety of cotton was again employed. Stand counts and seasonal wilt counts were made as in Experiment I. Except for one year's results, only the final wilt counts are presented.

The complete results for 1933 are presented in Table 3. They serve to illustrate the general organization of the experiment. When the experiment was set up, a series of plots employing stable manure at the rate of 10 tons per acre was planned. However, no applications were made on these plots in 1932, and, therefore, only 3 years' results with stable manure were secured. In order to illustrate the complete set-up, all wilt counts and the yields of seed cotton are presented for 1933 rather than for 1932, the first year of the experiment.

Complete final results for each of the 4 years are presented in Table 4.

The experiment was designed to study the effects of various balanced and unbalanced fertilizers on the incidence and severity of potash hunger and cotton wilt. The plots, as in the previous experiment, were carefully located by means of permanent markers, and each row received exactly the same treatment each year during the time of the experiment. In short, the non-fertilized checks were without fertilizer throughout the 4-year period and the fertilized plots received the same amount of fertilizer each year over the same period. Such a technique theoretically should result in cumulative effects, the checks and unbalanced plots becoming progressively more unfavorable for the growth of cotton and more favorable for the development of wilt and "rust," and the plots receiving balanced applications becoming more fertile if residual effects are actually present.

A study of the incidence of wilt on non-fertilized checks on the Govan Place during the 7-year period covered by Experiments I and II gives conclusive evidence of the great effect that weather has upon the incidence of wilt and likewise upon the yield of seed cotton. In this period, Trice 304 cotton on the non-fertilized plots varied in the incidence of wilt from 10.5 to 40.7 per cent, and the yield of seed cotton on checks varied from 233 to 769 pounds per acre. In view of this extreme variation from year to year on non-fertilized land, largely because of weather factors undoubtedly, comparisons from year to year are difficult.

Examination of the data in Table 4 shows that the relation between the incidence of wilt and yields of seed cotton in treated and non-treated plots is by no means invariable from year to year.

However, in most years the relationship is surprisingly uniform. Nitrate of soda applied alone at the rate of 240 pounds gave an incidence of cotton wilt varying from 8.9 per cent to 24.4 per cent, and at the same time yields have ranged from 428 pounds of seed cotton to 1,123 pounds. Decreases in the incidence of wilt were especially clear cut and consistent when high potash applications were made alone or in a mixed fertilizer. Phosphorus applied alone in every case resulted in an increase in the incidence of wilt, the actual portions of wilted plants varying from 12.3 to 40.8 per cent; applications of phosphorous and nitrogen without potash gave increases in the incidence of cotton wilt in the last 2 years of the experiment. One of the extremely noticeable results of the applications of phosphate alone and with nitrogen was a preliminary stimulation resulting in larger plants followed by very marked accentuation of the symptoms of potash hunger, including reddening and death of foliage, early defoliation and death of plants, and failure of the top bolls to mature and open.

Considerable evidence of a residual fertilizer effect is to be noted. Applications containing potash have in most cases resulted in progressively less cotton wilt from year to year compared to the incidence of wilt in the checks, which is also associated with slight progressive gains in the yield of seed cotton. In the case of the no-potash applications, the incidence of cotton wilt compared to the non-fertilized checks showed a decided increase, and, in the case of the phosphate plots, yields fell off decidedly the last 2 years of the experiment. A much longer series of years would seem necessary in order to prove definitely any trends associated with residual fertilizer effects, but there is seemingly a definite tendency in that direction.

The experiment, however, points clearly to an association between the use of unbalanced, non-potash fertilizers and an increase in the incidence of potash hunger over that found in non-fertilized plots, and this increase in the incidence of potash hunger seems likewise definitely associated with increases in the incidence of the cotton wilt disease and with detrimental effects on the yield of seed cotton.

Experiment III

Work on this experiment was begun in 1933 and extended through the season of 1937. The work was carried out on the Brittain Place near the Cotton Branch Experiment Station in Lee County, Arkansas.

The success of the preliminary work reported under Experiment I suggested the possibility of using a somewhat more wilt-resistant variety of cotton than Trice 304, together with vari-

ous fertilizer combinations to determine whether or not the methods previously employed would be successful when applied to a variety which, under field conditions, had been shown to be decidedly more resistant to the cotton-wilt disease. Arkansas Rowden 2088 was the variety selected, and, for comparison with it, the susceptible variety Missdel was used. During the period of this experiment, 1933 to 1937, inclusive, three strains of Missdel were used, viz., Missdel 2, Missdel 3, and Missdel 4, but the more resistant variety Rowden 2088 was used throughout.

Method and time of fertilizer placement, thinning and the like were essentially the same as those described for Experiments I and II. The experimental plots were located about a mile from those used in the two earlier experiments, and the soil and cotton wilt situation were somewhat similar. In this experiment and in the previous work, an attempt was made to plant cotton as near as possible to the optimum planting date. Complete data for the first year are presented in order to give a more complete picture of the set-up.

Table 5 shows the set-up of this experiment, the seasonal incidence of wilt and the yields of seed cotton for the year 1933. As in the previous experiments, all plots and rows in plots were permanently located so that the results might be compared from year to year as far as possible.

Complete final results for this experiment over the 5-year period, 1933-1937, are given in Table 6.

As in Experiments I and II, great variations in yields and in the incidence of cotton wilt attributable to seasonal conditions appeared, making comparisons over a period of years difficult. The non-fertilized plots of the two cotton varieties show well the difference in the susceptibility to the disease of the two varieties used, variety Rowden 2088 being consistently much more resistant to attack than the strains of Missdel. However, since it proved impossible to use the same strain of Missdel throughout the experiment, it is impossible to make anything more than general comparisons of the two varieties.

It is to be noted that all of the fertilizers employed, including the 6-8-0 treatment, in most cases gave at least slight reductions in the incidence of cotton wilt over the non-fertilized checks.

Clear-cut reductions in the incidence of wilt were most evident when the fertilizer applications contained a considerable amount of potash. Expressed as K_2O the treatments used contained potash in the following amounts: None, 72, 24, 20, 68, and 30 pounds, respectively. From the point of view of the reduction in incidence of cotton wilt, there is some evidence that the applications in the form of kainite were slightly more effective than were the muriate applications as parts of mixed fertilizers.

TABLE 5. EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON THE INCIDENCE OF COTTON WILT AND YIELD OF SEED COTTON IN RELATION TO CERTAIN VARIETIES, BRITTAIN PLACE NEAR COTTON BRANCH EXPERIMENT STATION, LEE COUNTY, ARKANSAS, 1933[1]

Plot treatment		Variety	Wilted plants					Acre yield of seed cotton
Formula	Amount applied per acre		July 6	July 21	Aug. 7	Aug. 21	Sept. 6	
			Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Pounds*
6-8-0	Nitrate of soda, 240 pounds Superphosphate, 300 pounds	Missdel 2 Rowden 2088	6.6 1.6	13.4 2.3	18.4 2.3	25.0 2.4	34.5 2.8	1072 1278
6-8-12	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 144 pounds	Missdel 2 Rowden 2088	7.5 2.0	9.7 2.0	10.2 2.0	12.7 2.0	16.4 2.1	1424 1573
6-8-4	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 48 pounds	Missdel 2 Rowden 2088	10.3 2.1	13.9 2.4	15.7 2.4	19.1 2.7	27.3 3.4	1134 1357
0-0-3.33	Kainite, 20 per cent, 100 pounds	Missdel 2 Rowden 2088	7.8 2.4	12.2 2.7	15.4 2.7	18.6 2.9	25.5 3.3	1019 1019
0-0-11.33	Kainite, 20 per cent, 340 pounds	Missdel 2 Rowden 2088	7.4 2.2	9.6 2.4	10.0 2.4	11.5 2.4	11.6 2.4	1061 1037
0-0-5	Kainite, 20 per cent, 150 pounds	Missdel 2 Rowden 2088	7.4 1.7	8.9 2.0	9.3 2.0	11.0 2.0	14.9 3.2	947 1132
Check	No treatment	Missdel 2 Rowden 2088	10.7 4.5	15.4 4.5	18.9 4.6	27.4 5.0	35.0 5.9	794 954

[1] Planted in duplicate series. Total plant count, 16,572.

TABLE 6. EFFECTS OF VARIOUS FERTILIZER TREATMENTS ON THE INCIDENCE OF COTTON WILT AND YIELD OF SEED COTTON IN RELATION TO CERTAIN VARIETIES, BRITTAIN PLACE NEAR COTTON BRANCH EXPERIMENT STATION, LEE COUNTY, ARKANSAS, 1933-1937[1]

Plot treatment		Variety	Wilted plants					Yield seed cotton per acre				
Formula	Amount applied per acre		1933	1934	1935	1936	1937	1933	1934	1935	1936	1937
			Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
[illegible]	Nitrate of soda, 240 pounds Superphosphate, 300 pounds	Missdel	34.5	37.8	27.5	32.0	16.6	1072	732	647	404	770
		Rowden 2088	2.8	4.3	4.9	5.5	4.0	1278	1095	811	956	1218
[illegible]-12	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 144 pounds	Missdel	16.4	14.8	5.6	15.9	9.5	1424	1052	840	732	1658
		Rowden 2088	2.1	2.8	.8	2.6	.4	1573	1407	1051	832	2312
6-8-4	Nitrate of soda, 240 pounds Superphosphate, 300 pounds Muriate of potash, 48 pounds	Missdel	27.3	26.9	12.5	20.9	13.3	1134	893	756	598	1320
		Rowden 2088	3.4	2.4	2.6	3.7	1.9	1357	1211	985	1178	1912
0-0-3.33	Kainite, 20 per cent, 100 pounds	Missdel	25.5	25.5	10.4	18.4	8.6	1019	723	572	622	1044
		Rowden 2088	3.3	2.7	2.0	3.3	1.7	1019	1000	733	976	1276
0-0-11.33	Kainite, 20 per cent, 340 pounds	Missdel	11.6	11.0	6.9	12.8	5.1	1061	912	590	632	1264
		Rowden 2088	2.4	2.0	.3	2.1	.6	1037	1061	705	934	1360
0-0-5	Kainite, 20 per cent, 150 pounds	Missdel	14.9	16.5	4.3	10.5	4.4	947	724	519	642	1042
		Rowden 2088	3.2	1.5	1.3	2.5	.6	1132	960	695	918	1212
[illegible]	No treatment	Missdel	35.0	51.1	25.3	27.9	22.5	794	479	402	517	826
		Rowden 2088	5.9	8.3	6.7	10.6	5.4	954	720	564	791	866

[1] Planted in duplicate series. Total plant count for the period, 91,287.

However, 340 pounds of kainite has shown little, if any, advantage over half that amount. It seems clear also that the amounts of potash contained in 100 pounds of kainite and in the 6-8-4 application were insufficient to secure optimum results.

In the 5-year period the yields of Rowden 2088 consistently exceeded those of Missdel, except in two series of treatments in 1933. This suggests that cotton wilt greatly reduced the yields of the Missdel variety. It is recognized, however, that other factors, such as the suitability of Rowden 2088 for the particular site used and its probable inherently better yielding qualities, may have a considerable part in this result. It is believed that the incidence of cotton wilt in practically all of the fertilized Rowden plots was too low to have any significant effect upon yields, and that the yield increases with respect to this variety were largely, if not wholly, attributable to the direct fertilizer of the applications rather than to control of the wilt disease.

The results presented suggest that, under the conditions of this experiment, the combination of a somewhat wilt-resistant variety with a fertilizer containing a moderate amount of potash is most effective. In common with all of the work reported previously in this bulletin, the application of potash fertilizer has resulted consistently in substantial reductions in the amount of cotton wilt.

Experiment IV

Considerations of expediency have resulted in locating most of the experimental work on the relation of fertilizers to the cotton wilt disease in the vicinity of the Cotton Branch Experiment Station. Therefore, when opportunity arose in 1930 and 1931 to obtain information regarding cotton wilt and yields of seed cotton from a series of fertilizer demonstrations located in central, eastern, and northeastern Arkansas, it seemed desirable to supplement the more intensive work already reported.

Since it was impossible to visit these sites but once, counts were made as late in the season as possible. In 1930 drought conditions were severe and the last part of August appeared to be the latest time at which reliable counts could be secured, but in 1931 conditions were unusually favorable for the late growth of cotton. Consequently, it was not necessary to make counts until October 1. It should be noted that late season counts fail to give a complete picture of the cotton-wilt situation, since those plants that are affected severely early in the season often die and disappear by midsummer. The wilt counts presented in Experiment IV may, therefore, be regarded as representing something less than the total incidence of the disease.

[3] The author acknowledges the cooperation of Earl Kilpatrick of Marianna, Arkansas, who made it possible to secure data on these fertilizer tests both in 1930 and 1931.

Because of limitations of time, it was impossible to make complete counts of all the plants in each treatment. In general, it may be stated that 100 feet was measured off on each of two rows of each plot and every plant in that area carefully examined by cutting into the stem near the soil line to determine whether or not vascular discoloration was present. Plants were also

TABLE 7. EFFECTS OF FERTILIZER TREATMENTS ON THE INCIDENCE OF COTTON WILT AND YIELD OF SEED COTTON AT POINTS IN CENTRAL, EASTERN, AND NORTHEASTERN ARKANSAS, 1930 AND 1931

Treatments[1]	Rate of cotton wilt	Yield of seed cotton per acre
	Per cent	*Pounds*
Section A[2]—North Little Rock, 1930		
Check—no treatment	36.39	609
6-8-0	35.00	960
6-8-4	35.20	888
6-8-8	41.20	738
6-8-12	26.40	987
Section B[3]—Scott, 1930		
6-8-0	11.98	384
6-8-12	0.58	726
Section C[4]—Altheimer, 1930		
6-8-0	19.30	[illegible]
6-8-12	1.10	[illegible]
Section D[5]—Wynne, 1930		
6-8-0	54.00	927
6-8-12	21.00	1431
Section E[6]—Paragould, 1930		
Check—no treatment	18.45	558
6-8-0	23.79	738
6-8-4	13.53	774
6-8-8	6.45	672
6-8-12	3.25	810
Section F[7]—Beech Grove, 1930		
Check—no treatment	19.91	642
6-8-4	24.02	684
6-8-12	25.96	930
Section G[8]—Forrest City, 1930		
6-8-0	16.00	1020
6-8-12	6.34	1464
Section H[9]—Palestine, 1931		
6-8-0	20.70	420[15]
6-8-12	10.00	468[15]
Section I[10]—Wheatley, 1931		
6-8-0	25.30	786
6-8-12	5.20	870
Section J[11]—Colt, 1931		
Check—no treatment	32.60	608
100 lbs. Muriate of potash per acre	20.50	720
Section K[12]—Wynne, 1931		
No treatment	17.40	868
100 lbs. Muriate of potash per acre	7.69	848
Section L[13]—Barton, 1931		
Check—no treatment	28.10	820
100 lbs. Muriate of potash per acre	5.90	1092
Section M[14]—Marvell, 1931		
Check—no treatment	60.80	1040
100 lbs. Muriate of potash per acre	43.60	1384

[1] All mixed fertilizers were applied at the rate of 600 pounds per acre.

[2] Variety, Rowden 2119; [3] variety, Rowden 40; [4] variety, D. & P. L. 4; [5] variety, Arkansas Acala 37; [6] variety, Arkansas Rowden 40; [7] variety, Unknown; [8] variety, Rowden 40; [9] variety, Rowden 40; [10] variety, Commercial Rowden; [11] variety, Unknown; [12] variety, Unknown; [13] variety, Unknown; [14] variety, D. & P. L. 4; [15] very poor stand.

dug up and examined for root knot or nematode disease. Notes were likewise taken on the varieties used, on the soil type, on the presence or absence of potash hunger, and on the effect of the treatments on plant growth. Arrangements were also made to secure yield records on each series of plots studied. The data secured are presented in Table 7. Location of the various plots in all of the experiments presented are shown in Figure 1.

As might be expected with such a wide variety of soils and cotton varieties and with two seasons as different as the drought year of 1930 and the unusually favorable conditions in 1931, there was great variation with respect to the incidence of the cotton-wilt disease both on fertilized and untreated plots. At Wynne and Barton, an application of 100 pounds of muriate of potash alone gave very marked reduction in the amount of cotton wilt. Even under the extreme conditions encountered at Marvell, where about 61 per cent of the plants in the checks of the partially resistant D. & P. L. 4 variety were affected, the incidence of wilt was reduced a third by the application of 100 pounds of muriate alone.

At Forrest City, Palestine, Wheatley, Wynne in eastern Arkansas, at Paragould in northeastern Arkansas, and at Scott in central Arkansas, the use of high-potash-containing mixed fertilizers resulted in very clear-cut reductions in the amount of cotton wilt. However, at North Little Rock in central Arkansas, no benefit was secured, and at Beech Grove, in the northeastern part of the state, the use of a potash-containing fertilizer was entirely ineffective so far as cotton wilt was concerned, although the severity of "rust," or potash hunger, was greatly reduced.

At North Little Rock, using the moderately resistant Arkansas Rowden 2119 variety, no potash hunger was to be noted, in marked contrast to practically all of the other sites studied, but wilted plants were without exception badly affected with root knot as well as cotton wilt. The conditions at North Little Rock are typical of many areas in the Arkansas River Valley of central Arkansas where, with sandy river bottom soil, root knot and cotton wilt together cause heavy damage. Experience in Arkansas agrees with the results which have been reported by workers for many years; namely, that attacks of the root-knot disease greatly increase the susceptibility even of wilt-resistant varieties of cotton. It now appears further that the value of potash fertilizers for the control of wilt may be greatly reduced when root knot is present.

In spite of the fact that root knot was not a factor and that conditions simulating, at least, typical potash hunger were very prevalent at the Beech Grove site, no benefit with respect to the cotton-wilt disease was noted from the use of as much as 600 pounds of a 6-8-12 fertilizer; these results are difficult to

explain. That such results may be expected at times is shown by the work of Lewis (*3*) in Georgia, Orton (*10, 11*) in the eastern cotton states, Fulton (*2*) in Louisiana, and Walker (*13*) in Florida, which indicate that potash-containing fertilizers cannot be relied on in all cases to ameliorate the cotton-wilt situation.

GENERAL DISCUSSION OF RESULTS

The results reported in this bulletin were secured over a period of 9 years, during which time studies were made at 15 separate locations, mostly in eastern Arkansas with some in northeastern and central Arkansas. At 13 of these sites, data were secured for one year, but work on the Govan Place extended from 1929 to 1935, inclusive, a period of 7 years, and on the Brittain Place, from 1933 to 1937, inclusive, a period of 5 years. These two latter locations are near the Cotton Branch Experiment Station. Soils in all cases were of alluvial origin, varying from the sandy river bottom soils of the central Arkansas River Valley to the much finer, heavier silt loams found in eastern Arkansas. Although in certain seasons cotton wilt is prevalent locally in the heavier Mississippi Delta soils, it is much less destructive and much less important on these soils. No experiments have been carried out on such delta soils, or on the clay upland soils where little cotton wilt is found. Sites have been selected where cotton wilt was known to have been destructive in previous years and an attempt was made to avoid nematode infested soils. Although no attempt was made to select sites on the basis of potash deficiency, it was generally found that "rust," or potash hunger, was a complicating factor.

The treatments used in the course of the experiments may be roughly grouped as follows:

(1) Checks, no fertilizer applied.
(2) Application in varying amounts of potash alone in the form either of muriate of potash of kainite.
(3) Application in varying amounts of muriate of potash together with uniform amounts of nitrate of soda and superphosphate.
(4) Applications in varying amounts of nitrate of soda alone.
(5) Applications of superphosphate alone.
(6) Applications of nitrate of soda and superphosphate.
(7) Applications of superphosphate and muriate of potash.
(8) Applications of nitrate of soda and muriate of potash.
(9) Applications of cottonseed meal at the rate of 600 pounds per acre.
(10) Applications of stable manure at the rate of 10 tons per acre.

The varieties of cotton employed have included such comparatively susceptible varieties as Trice 304, Missdel 2, Missdel 3, Missdel 4, and Arkansas Acala 37, and such moderately resistant

varieties as Arkansas Rowdens 40, 2119, and 2088. This list includes no varieties which are extremely susceptible to cotton wilt, such as Half & Half and Coker 100, nor does it include any varieties which are extremely resistant to cotton wilt, such as Dixie 14, Dixie Triumph, various strains of Clevewilt, and various strains of Cook. As has been mentioned, root-knot nematode infestations were deliberately avoided, only one of the 15 sites studied being infested with this organism.

The results may be summarized as follows: On non-treated plots cotton plants were likely to be smaller and subject to potash hunger, varying greatly with the season. The incidence of cotton wilt varied greatly from site to site and from year to year, and naturally from variety to variety. The partially resistant Arkansas Rowden strains seldom gave a high incidence of cotton wilt even where no potash was used, the exception being at North Little Rock, where, with a serious nematode infestation, non-treated plots of Rowden 2119 gave more than 36 per cent wilt. Susceptible varieties commonly showed as much as 30 to 60 per cent of wilted plants in nematode-free soils when both potash hunger and cotton wilt occurred.

Applications of potash alone, either as kainite or muriate of potash, reduced potash hunger at the lowest level used, but higher amounts of potash alone seemed to give correspondingly greater reductions in the incidence of cotton wilt with both resistant and susceptible varieties, although yields were commonly not as good as when a mixed fertilizer was used.

In no case was there found to be more cotton wilt with a higher application of potash than with a lower application. There were slight indications that kainite was more efficient for cotton-wilt control than muriate containing an equal amount of potash. Further work is needed to determine whether or not the other chemical elements present in kainite have any effect on the incidence of cotton wilt.

The question of the effect of organic fertilizers on the incidence of cotton wilt is one of considerable importance. Fulton (*2*) has shown that heavy applications of stable manure may reduce the incidence of cotton wilt by one-half and that green manures have a similar, though less marked, effect. Young, Ware, and Janssen (*15*) failed to secure any reduction in the incidence of cotton wilt when green manures, mostly legumes, were used in pot experiments. In the 3-year experiment on the Govan Place, previously described, cottonseed meal at the rate of 600 pounds per acre applied under the seedbed was completely ineffective in controlling cotton wilt, although yields of seed cotton were increased. On the other hand, stable manure broadcast at the rate

of 10 tons per acre resulted in decreases in the incidence of wilt comparable to those secured by Fulton (*2*) who used much larger applications in Louisiana. At the same time "rust" was perfectly controlled. It is quite obvious that experience in a given area is necessary in order to determine whether or not a particular fertilizing program is of any value whatsoever. It is also obvious that in view of the varying results with experiments in different parts of Arkansas, both with respect to fertilizers and with respect to cotton varieties, anything like a generalization regarding the control of cotton wilt through the use of resistant varieties and fertilizers is impossible.

Of the 15 sites where cotton wilt data were secured, potash-containing fertilizers were found to cause some reduction in the amount of cotton wilt in all but two, one of which was a site severely infested with nematodes. In the light of much previous experience in all parts of the cotton area of the United States, it seems futile to expect that any of the available control measures for the cotton-wilt diseases will be nearly as efficient when root knot is a complicating factor. In view of the many reports of severe nematode infestations in the sandy coastal plains of Florida, Georgia, and possibly other southeastern states, it is worthwhile to consider whether or not the negative results obtained by Orton (*10*, *11*), Lewis (*3*), Walker (*13*), and Fulton (*2*) with potash-containing fertilizers can be attributed, in part at least, to the serious loss of resistance to cotton wilt which even the more wilt-resistant varieties of cotton exhibit when affected with root knot.

In general it may be said that the results secured in these experiments are essentially similar to those of Neal (*7*, *8*, *9*) and Miles (*4*, *5*, *6*) in Mississippi and Sherbakoff[4] in Tennessee. In an experiment in 1935 on light, buck-shot soil in West Tennessee, Sherbakoff (*1*) found that only the potash-nitrogen combination gave indication of reducing the amount of wilt in the susceptible variety; (2) that a reduction of the amount of wilt in the resistant variety was obtained from all combinations containing potash; (3) that the amount of wilt was increased in both the resistant and the susceptible varieties by the phosphate-nitrogen combination. The results reported by Sherbakoff with respect to the effects of potash-containing fertilizers and of nitrogen-phosphorus combinations, which resulted in decreases in the incidence of cotton wilt for the former and in increases in the amount of wilt for the latter, are essentially in agreement with the results in Arkansas.

[4] See footnote on page 4.

SUMMARY

The relation of fertilizer application to the control of cotton wilt and "rust," or potash hunger, has been studied at 15 different sites where cotton wilt occurred in central, eastern, and northeastern Arkansas.

Plot work extended over the period 1929-1937 and included the application of complete fertilizer (NPK), and these substances alone and in combination at different levels. Cottonseed meal and stable manure were also used.

Fertilizers containing potash in every year and in every location, except two, gave control of "rust," and gave reductions in the incidence of cotton wilt. Heavier applications of potash were, in general, more efficient than low applications for the control of cotton wilt, but excessively high applications of potash were without correspondingly greater result. Nitrate alone had little or no effect on the incidence of cotton wilt, but acid phosphate and nitrate, and particularly acid phosphate alone, seemed actually to increase the incidence of both cotton wilt and "rust," or potash hunger.

Cottonseed meal was completely ineffective so far as the control of either "rust" or cotton wilt was concerned, but stable manure at the rate used gave clear-cut control of "rust" and some decrease in the incidence of cotton wilt.

There was some indication that applications containing potash were cumulative in their effect on the control of both cotton wilt and "rust"; and, on the other hand, applications lacking potash seemed to cause an unbalanced soil condition which resulted in increasingly greater damage from both wilt and potash hunger. Much more work along this line is needed before definite conclusions can be drawn.

Although applications of potash alone often gave as good or even better results in cotton-wilt control than the same amount of potash in a mixed fertilizer, the latter generally gave better yield responses. No cases were found where high applications of potash either alone or in a mixed fertilizer resulted in increases in the incidence of either cotton wilt or "rust" over lower applications.

Potash hunger, or "rust," was associated with cotton wilt at all of the 15 sites studied, except one where root knot, or nematode disease, was associated with a severe attack of the cotton-wilt disease.

The combination of a moderately wilt-resistant variety of cotton with the use of a potash-containing fertilizer generally resulted in marked reduction in the incidence of cotton wilt, but, when root knot was present, potash applications and varietal re-

sistance both proved to be ineffective for the control of cotton wilt.

The great variation in the effectiveness of potash fertilizers at different sites and the marked effect of weather on the severity of cotton-wilt attacks indicate that there will be great variations in the efficacy of cotton-wilt control measures from year to year and from place to place. It thus appears that nothing short of field studies, carried out over a period of years in practically every locality where cotton wilt is a factor, may be expected to determine just what combinations of varieties and fertilizer will provide the most satisfactory control of the cotton wilt-"rust" problem in any given locality.

The data reported provide no definite explanation of the beneficial effect of potash-containing fertilizers for the control of cotton wilt beyond the observation that such effects in all cases have been associated, to a greater or lesser degree, with the control of "rust," or potash hunger, and beyond the further observation that potash hunger and cotton wilt have been repeatedly found in an aggravated form when unbalanced applications lacking potash, and especially applications of phosphate alone, are made. Studies are now in progress in this laboratory looking to an explanation of the physiological basis for the observed facts.

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